Pectoralis Major Muscle Rupture Repair: Technique Using Unicortical Buttons

LT Paul D. Metzger, M.D., MC, USN, LCDR James R. Bailey, M.D., MC, USN, ENS Robert D. Filler, B.S., MC, USN, LCDR Robert A. Waltz, M.D., MC, USN, CDR Matthew T. Provencher, M.D., MC, USN, and LCDR Christopher B. Dewing, M.D., MC, USN

Abstract: Over the past few decades, there has been increased awareness of pectoralis major muscle injuries necessitating further evaluation of management options and, in particular, surgical repair. Injury typically occurs when an eccentric load is applied to the muscle, such as with bench pressing, and failure usually occurs through the tendon. Although nonoperative management is sometimes appropriate, given the injury's propensity for young, active male patients, surgical intervention is often warranted. Because the injury typically occurs at the muscle-tendon interface, surgery focuses on repair of the avulsed tendon into its anatomic attachment site. We describe the use of a unicortical suture button to repair the ruptured tendon. This technique achieves the goals of strong fixation and anatomic repair of the tendon back into its native footprint.

Injury of the pectoralis major muscle was first described in 1822 by Patissier. The injury then went largely undocumented in the literature until the 1950s. Before the 1970s, it was considered a rare injury, generally occurring as an occupational injury. A rise in the popularity of recreational weightlifting, particularly bench pressing, has since accounted for an increased incidence and awareness of pectoralis major injuries. We present a novel technique for pectoralis major repair using a unicortical suture button technique.[1]

ANATOMY AND FUNCTION

The pectoralis major muscle originates along the lateral sternum and inferior clavicle and inserts along the proximal humerus on the lateral lip of the bicipital groove.[1-5] The functions of this muscle include internal rotation, forward flexion, and adduction of the shoulder.[1] The muscle achieves this action through a broad insertion originating from 2 heads, sternal and clavicular. The footprint is located approximately 4 cm distal to the greater tuberosity on the lateral lip of the bicipital groove and measures approximately 70 mm (proximal to distal) × 1.4 mm (medial to lateral).[2] There is also a well-conserved musculotendinous twist proximal to the bony insertion site, with the sternal limb inserting proximal and deep to the clavicular limb.[2-5] Surgical repair should ideally reapproximate this anatomy to achieve optimal functional and cosmetic results.

From the Department of Orthopaedic Surgery, Shoulder, Knee and Sports Surgery, Naval Medical Center San Diego, San Diego, California, U.S.A.

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Address correspondence to CDR Matthew T. Provencher, M.D., MC, USN, Department of Orthopaedic Surgery, Naval Medical Center San Diego, 34800 Bob Wilson Drive, San Diego, CA, U.S.A. E-mail: mattprovencher@earthlink.net

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Table 1. *Surgical Outcomes*

Reference	Year	Study Type	No. of Surgical Patients	Surgical Outcomes	Comments
Kretzler and Richardson[9]	1989	Retrospective case series	16	13/16 (81.3%) return to full strength	15/16 regained full motion
Wolfe et al.[12]	1992	Retrospective case series	7	6/7 (85.7%) excellent	105.8% peak torque and 109% work performed compared with uninjured side
Pavlik et al.[10]	1998	Retrospective case series	7	100% excellent/good	6/7 returned to sports at preinjury levels
Bak et al.[7]	2000	Meta-analysis	57	50/57 (88%) excellent/good	Significantly more excellent outcomes if surgery performed within 8 wk of injury
Schepsis et al.[14]	2000	Retrospective case series	13	96% satisfied in acute group and 93% satisfied in chronic group	Satisfaction score based on average of pain relief, range of motion, strength, and cosmesis scores
Hanna et al.[8]	2001	Retrospective case series	9	9/9 (100%) excellent/good	99% peak torque regained and 97% work performed compared with uninjured side; all patients returned to work and/or sports
Kakwani et al.[11]	2007	Retrospective case series	13	12/13 (92.3%) excellent/good	11/13 returned to sports at preinjury levels; 1 rerupture at 3.5 mo during a fight
He et al.[13]	2010	Retrospective case series	9	8/9 (89%) excellent/good	8/9 returned to sports at preinjury levels
de Castro Pochini et al.[6]	2010	Prospective cohort	10	9/10 (90%) excellent/good	7/10 returned to sports at preinjury levels; 13.7% peak torque deficit at 60°/s abduction

PATHOPHYSIOLOGY

Pectoralis major "tears" most commonly occur at the bone-tendon insertion as an avulsion injury. Less commonly, there is an intrasubstance tear. The most common mechanism of injury is rapid eccentric loading of the muscle, as in bench pressing, which places the shoulder in an abducted, externally rotated position with maximal muscle tension at the bottom of a repetition after the weight is lowered to the lifter's chest.[1] This mechanism of action explains why the vast majority of injuries occur in younger, highly active male patients engaging in strenuous physical activity. The medical literature shows a high rate of injury in weightlifters and an association with anabolic steroid use.[6]

TREATMENT OPTIONS

Options for treatment include surgical repair versus nonsurgical management, primarily physical therapy. Surgery is generally indicated to repair a complete tear of the muscle. Nonsurgical management yields satisfactory results in patients with sedentary lifestyles, because pectoralis major muscle weakness is generally well tolerated.[1] Predictably, the patient population most likely to have a pectoralis major injury is the same population most likely to have disability from decreased pectoralis muscle function. In younger, active patients, surgical repair is indicated, and a review of recent literature has found surgery to yield excellent functional and cosmetic results (Table 1).[6-14]

PREOPERATIVE EVALUATION

The diagnosis of pectoralis major muscle injuries has previously been described in the literature.[1] Clinically, the injury is acute in onset, followed by weakness, pain, and swelling. In the acute setting, physical examination shows ecchymosis around the site of injury and muscular deformity; examination alone is usually satisfactory to determine whether rupture requiring surgical intervention has occurred. Multiple imaging modalities have been studied to assist in cases where it is less clear whether complete rupture has occurred and to aid in preoperative planning. Plain films can be used to evaluate for bony injury. Magnetic resonance imaging is the gold standard for evaluation of soft-tissue injury, al-

TABLE 2. *Key Points, Tips, and Pitfalls*

Key points
Pectoralis major tears typically occur from rapid eccentric loading, most commonly while performing bench press–type exercises.
Surgical repair yields superior results to nonoperative treatment in active individuals.
The anatomic insertion footprint is along the lateral ridge of the bicipital groove and measures 70 mm in length.
The pectoralis major muscle consists of 2 heads: sternal and clavicular. The sternal head inserts proximal and deep to the clavicular head. This relation must be restored to achieve optimum function.
Surgical tips
Use of a padded Mayo stand to support the operative extremity allows for greater control and exposure.
Use the distal 6-8 cm through the standard deltopectoral approach; however, center the incision slightly medially to allow for easier identification of the retracted tendon.
Use residual tendon to aid in identification of the pectoralis major insertion footprint; place unicortical buttons at the proximal and distal ends of the footprint.
Pass only 1 limb of the FiberWire and FiberTape through the button to allow ease of suture sliding.
First, tighten and secure the FiberWire limbs to reduce the tendon to the footprint; then tighten and secure the FiberTape.
Surgical pitfalls
Identify and retract the biceps tendon and sheath medially to prevent injury or impingement.
Remain lateral to the conjoined tendon on initial dissection and avoid aggressive over-retraction to prevent injury to the musculocutaneous nerve.
Inadequate mobilization of the pectoralis major muscle medially will not allow adequate excursion, resulting in postoperative stiffness and external rotation deficit.

though recently, ultrasound has been gaining popularity as a fast, inexpensive means of evaluating this injury. Multiple techniques have been described for the surgical management of pectoralis major repair, although all rely on the concept of reattaching the muscle along its anatomic insertion point. We describe a technique of unicortical bone fixation using metal buttons in which suture is "slid" through the button to accomplish the repair.

SURGICAL TECHNIQUE

The patient is positioned in a modified beach chair at approximately 45°, and the arm is placed on a padded Mayo stand (Video 1, Table 2). We prefer this position, which allows for better control of the operative extremity and improved visualization. The preoperative examination should focus on the anterior axillary fold, which is normally traversed by the pectoralis major tendon. A palpable defect can be identified and is accentuated by abduction and external rotation of the shoulder. In addition, any intact fibers of the tendon can be palpated, and retracted tendon can be identified medially on the chest wall.

The operative extremity is sterilely prepared and draped, and the arm is placed on a padded Mayo stand in slight forward flexion, abduction, and internal rotation. A surgical marking pen is used to identify important landmarks in the surgical field, including the inferior boarder of the pectoralis major tendon (if any portion is present) and the coracoid. The surgical incision is then marked, typically 6 to 8 cm centered over the distal portion of the typical deltopectoral approach but slightly more medial, to allow for ease of repair and tendon retrieval.

After the skin incision has been made, careful dissection is performed medial to the deltoid with care to preserve the cephalic vein and retract it laterally. With retraction of the pectoralis tendon, there is a variable amount of scar tissue in the surgical field. One must use other landmarks, including the coracoid, associated conjoined tendon, and bicipital groove, to guide dissection. Care should be taken to stay lateral to the coracoid during the initial approach to avoid injury to medial neurovascular structures.

The lateral aspect of the bicipital groove is then exposed, while the surgeon is carefully protecting the biceps tendon. The insertion site at the distal aspect of the lateral bicipital groove is identified (Fig 1). Fibers of the clavicular head of the pectoralis major may remain intact into their insertion and can also be used as a reference. Evaluation of the clavicular and sternal heads of the pectoralis major is undertaken at this time. Most commonly, the rupture is isolated to the sternal head and can be found retracted just medial to the axillary crease. If it is chronic, there can be significant scarring of the tendon to the superficial and deep fascia and subcutaneous tissues, which must be dissected free so that the tendon can be freely brought over to its anatomic humeral insertion. This is best accom-

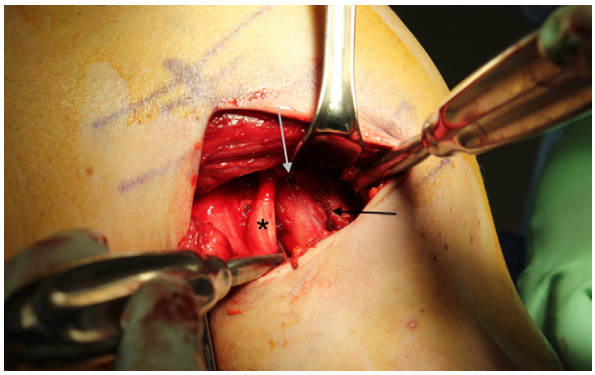

Figure 1. Left shoulder with patient in beach-chair position with shoulder flexed and internally rotated. A distal deltopectoral incision is made over the medial proximal humerus. Dissection is carried down to the proximal humerus until the bicipital groove is visualized. The lateral lip of the bicipital groove is exposed (black arrow), with care taken to preserve the overlying biceps tendon (asterisk). The fibers of the clavicular head (gray arrow) may still be intact and can aid in identifying the anatomic insertion.

plished with blunt dissection along the fascial plans superficial and deep to the tendon and muscle.

With the tendon being held with a Kocher clamp, the myotendinous unit is then whip-stitched with both FiberTape (Arthrex, Naples, FL), a high-strength ultrahigh-molecular-weight polyethylene and polyester nonabsorbable tape, in a running, nonlocking fashion and a No. 5 FiberWire (Arthrex), a nonabsorbable, high-strength suture. If, in addition, the clavicular head is partially or completely torn, it is stitched in a similar fashion. The pectoralis major has a very short tendon; therefore the repair construct must extend approximately 2 to 3 cm into the muscle to create an adequately strong repair. The high-strength tape is particularly important in this construct because its inherent shape minimizes pullout and shear in the muscular portion of the repair (Fig 2).

The anatomic insertion site of the pectoralis major tendon at the distal aspect of the lateral bicipital groove is then prepared with a rasp and partially decorticated to allow for bleeding bone. Two 3.2-mm spade-tipped drill pins (Arthrex) are drilled unicortically in parallel at the attachment site (Fig 3). It is important for the drill bits to be in the anatomic insertion point of the pectoralis major tendon to stay out of the bicipital groove. If too medial (in the biceps groove), the biceps may be incarcerated and potentially injured and has the potential for persistent pain.

The leading strands of both the superior and inferior sutures are then passed through separate titanium Pec Buttons (Arthrex) measuring 2.6 × 10.9 mm (Fig 4). Only 1 limb of each suture is sutured up and back down the tendon, such that a free limb to tie down and "slide" through the button is available. The suture must be kept untwisted as it passes through the eyelets to allow for easy sliding of the button during tendon tensioning. A 180° twist is then performed with the 2 strands of sutures, bringing the inferior portion of the sternal head proximal and deep to the clavicular head, re-creating the anatomic rotation of the tendon (Fig 5). Often, the clavicular head is left intact. In these cases the sternal head alone is brought back to its anatomic insertion site without a twist of the suture strands. The cortical buttons are then docked in an intramedullary manner through the appropriate holes with the button inserter (Arthrex); this

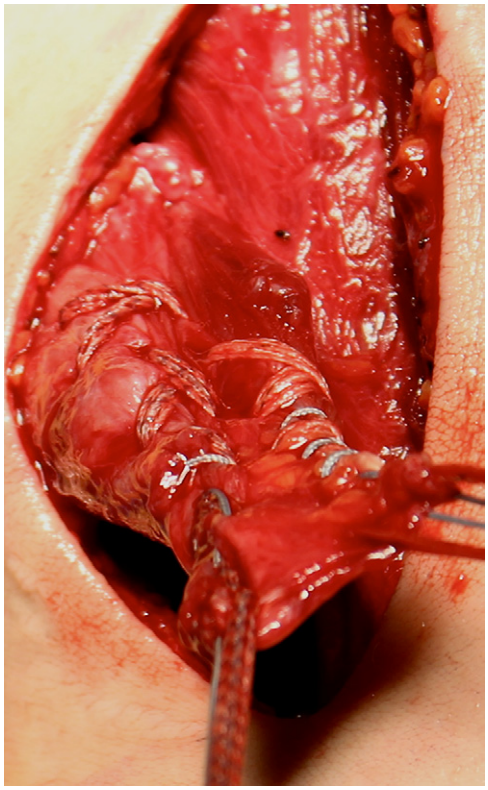

Figure 2. Left shoulder with patient in beach-chair position with shoulder flexed and internally rotated. The pectoralis major muscle–tendon unit has been identified and freed from surrounding soft tissue. Each head of the pectoralis major muscle and tendon is whip-stitched to provide an attachment for anchoring with a unicortical pectoralis button. Repair includes a high-strength suture tape to improving the strength of the repair by decreasing pull-through, given that the pectoralis has a very short tendon and repair must be advanced into the muscle belly.

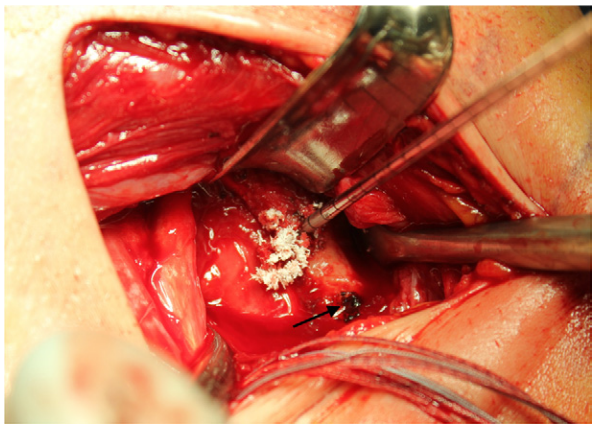

FIGURE 3. The anterior proximal humerus has been exposed, and the bicipital groove is identified. Spade-tipped drill bits are used to drill unicortical holes in parallel at the proximal and distal extent of the site of the original pectoralis major tendon footprint (the drill bit is proximal and the arrow is distal). These are then removed after drilling each unicortical hole along the lateral lip of the bicipital groove before inserting the cortical button.

is best accomplished by passing the eyelet with the trailing suture into the hole first so that the trailing suture can be toggled to seat the button on the inner cortex. The button should be passed obliquely into the hole and then rotated to help seat it. Finally, the leading ends of the suture are pulled to bring the tendon flush with the outer cortex of the humerus at the insertion site. By use of the leading suture and tape that were passed through the button as posts, the remaining free ends are tied together to secure the tendon to its native insertion. The high-strength suture should be tied first, followed by the tape, to adequately reduce the tendon (Fig 6).

The shoulder is brought through a gentle range of motion to confirm a stable repair. The wound is then copiously irrigated and closed in layered fashion, and sterile dressings are applied. Postoperatively, the patient's extremity is placed in a sling for comfort for 6 weeks. Early rehabilitation is started under the care of a trained physical therapist and focuses on early-passive and active-assisted range of motion. We allow flexion to 90°, abduction to 30° to 45°, and external rotation to 20° in the first 2 weeks; then range of motion is advanced progressively, as tolerated. Resistance training begins at 6 to 12 weeks postoperatively. Postoperative radiographs show the unicortical button position within the humerus (Fig 7).

ADVANTAGES AND LIMITATIONS

There are a number of advantages to the described technique for repairing the pectoralis major tendon. First, it is an anatomic repair of the tendon with reattachment of the tendon to its footprint and re-creation of the native anatomic course of the tendon. This is potentially advantageous from a clinical and cosmetic standpoint because it re-creates the native length-tension relation of the muscle, which optimizes the functional status of the muscle as close to preinjury level as possible. Next, the strength of the repair is maximized by use of 2 cortical buttons to bring the broad insertion of the avulsed tendon into direct contact with the anterior cortex of the humerus. The technique also decreases pull-through of the construct by using a broad high-strength tape to advance the repair into the muscle itself rather than limiting it to

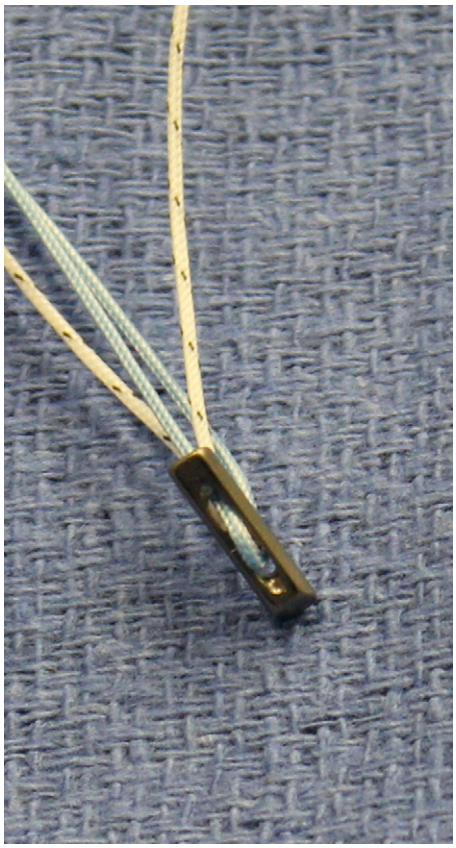

FIGURE 4. A close-up of the unicortical pectoralis button used for repair of the pectoralis major muscle, which is threaded onto the high-strength tape, and suture in each respective head of the pectoralis major muscle. The button is then inserted into a previously drilled hole at the pectoralis major insertion into the proximal humerus.

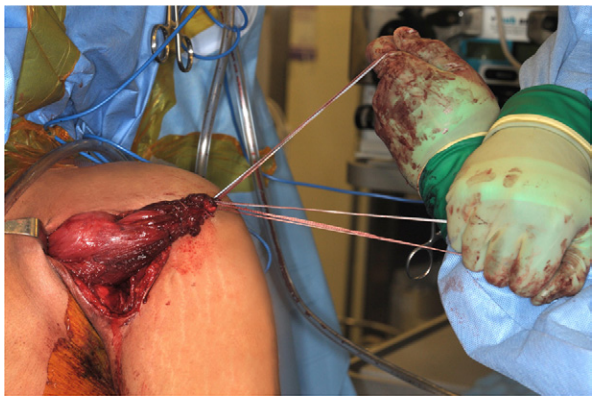

FIGURE 5. Left shoulder with patient in beach-chair position. The torn pectoralis major muscle has been exposed, and its 2 heads have been individually whip-stitched. In patients with both clavicular and sternal head tears, a 180° twist of the pectoralis major tendons brings the sternal head proximal and deep to the clavicular head and re-creates the native architecture at the repair site.

the relatively short tendon. Finally, the risk of iatrogenic injury to the posterior neurovascular structures, such as the radial nerve, is limited by using a unicortical button.

The main limitation of the described technique is that its role is limited to tendon avulsions and intratendinous injuries. It cannot be used for more proximal injuries at the myotendinous junction or intrasubstance tears of the muscle. In addition, although this technique can be used to repair chronic injuries, it is ideally suited to more acute ruptures because tension on the repair is significantly increased with chronic retraction of the muscle. Finally, although advancement of suture into the muscle improves the strength of the construct, it may have a negative impact on healing biology by potentially decreasing vascularity to the healing tendon.

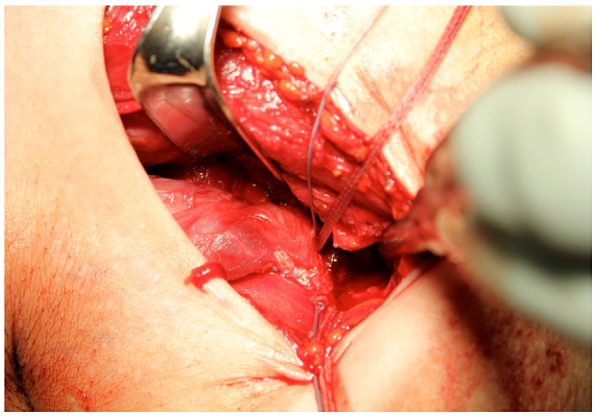

FIGURE 6. The pectoralis major tendon is anchored to the proximal humerus at its native insertion site with appropriate tensioning of the unicortical pectoralis buttons for fixation. The sutures are then secured with a knot and cut. This allows for appropriate contour and tension of the pectoralis major muscle.

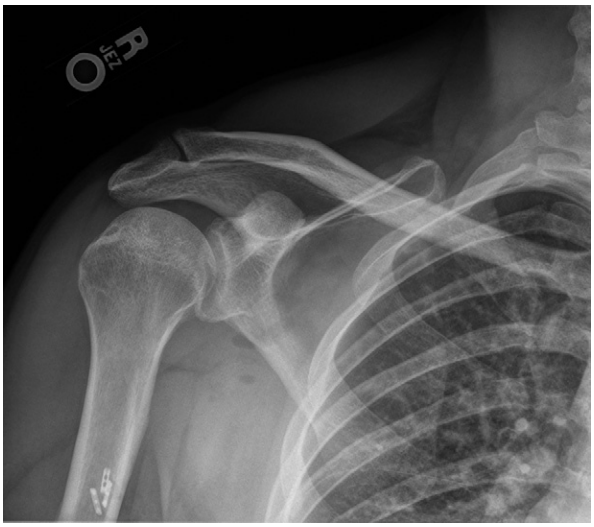

FIGURE 7. A postoperative radiograph showing the unicortical buttons within the medullary canal of the humerus. Of note, this patient also had a biceps tenodesis through the same incision with unicortical button fixation.

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